Lippmann's achievements. There are many who know the results of his practical work as director of the large sugar refinery at Halle, and of his researches in the laboratory, as comprised in his exhaustive two-volume treatise "Die Chemie der Zuckerarten," but there are fewer, perhaps, who know what he has done during leisure hours in the study along historical and cultural lines, as exemplified in his masterful book "Die Geschichte des Zuckers" and in these two volumes of scientific papers and essays. To be technologist, chemist, historian and scholar, and all surpassingly well, is a record of accomplishment such as few men have realized. Adapting a phrase from that ancient "father of science," Aristotle, of whose works Professor Lippmann is such an enthusiastic commentator, we may say: it is a record of accomplishment, "four-square and truly good."

C. A. BROWNE

SCIENTIFIC JOURNALS AND ARTICLES

THE July number (Vol. 14, No. 3) of the *Transactions of the American Mathematical Society* contains the following papers:

L. E. Dickson: "Proof of the finiteness of modular covariants."

R. D. Carmichael: "On transcendentally transcendental functions."

M. Fréchet: "Sur les classes V normales."

G. R. Clements: "Implicit functions defined by equations with vanishing Jacobian."

Dunham Jackson: "On the approximate representation of an indefinite integral and the degree of convergence of related Fourier series."

L. P. Eisenhart: "Certain continuous deformations of surfaces applicable to the quadrics."

THE concluding (July) number of volume 19 of the *Bulletin of the American Mathematical Society* contains: Report of the April meeting of the Society, by F. N. Cole; Report of the twenty-third regular meeting of the San Francisco Section, by W. A. Manning; "The total variation in the isoperimetric problem with variable end points," by A. R. Crathorne; "A note on graphical integration of a function of a complex variable," by S. D. Killam; "The unification of vectorial notation," by E. B. Wilson; "Shorter Notices": Kowalewski's Grundzüge der Differential- und Integralrechnung, by R. L. Borger; Vivanti-Cahen's Fonctions polyédriques et modulaires, by G. A. Miller; Markoff-Liebmann's Wahrscheinlichkeitsrechnung, Carvallo's Calcul des Probabilités et ses Applications, and King's Elements of Statistical Method, by A. C. Lunn; "Notes"; "New Publications"; Twenty-second Annual List of Published Papers; Index of Volume XIX.

THE RUTHERFORD ATOM

To explain the observations made by Geiger and Marsden[1] on the scattering of α particles through large angles by metal foils, Rutherford[2] suggested that in such cases the deflection of each ray was due to an intimate encounter with a single atom of the matter traversed. It was necessary to assume that the positive charge is highly concentrated in a very small volume at the center, surrounded by an equal amount of negative electricity distributed throughout the remainder of the volume of the atom. To compare the theory with experiment, suppose we consider the effect of allowing a narrow pencil of α rays to strike a thin metal foil from a direction perpendicular to its surface. The probable number of reflected or deflected rays which may be expected each second to strike any given square centimeter of a spherical screen whose center of curvature is the point of bombardment, was shown by Rutherford to be, according to his theory,

$$P = \frac{Qnt}{4r^2}\left(\frac{NeE}{mu^2}\right)^2 \operatorname{cosec}^4\frac{\phi}{2},$$

where:

Q = number of α rays striking the foil per second;

nt = number of atoms in the foil per unit area;

r = radius of the spherical screen;

ϕ = angle between the radius vector to the area and the direction of the striking beam of rays; or the angle of deflection;

Ne = central charge of the bombarded atom;

[1] *Proc. Roy. Soc.*, 82A: 495, 1909; 83A: 492, 1910; *Manchester Lit. and Phil. Soc. Proc.*, 1910.

[2] *Phil. Mag.*, 21: 669, 1911.

E = charge of an α ray;
m = mass of an α ray;
u = velocity of an α ray.

More recently, Geiger and Marsden[3] have performed a very thorough series of experiments which verify this formula, within an experimental error of about 20 per cent., for wide variations of nt, u and ϕ. In addition, by testing foils of various metals they found that P is proportional to the square of the atomic weight of the bombarded metal, other things being the same. Their experiments prove, then, that, for gold, platinum, tin, silver, copper and aluminium,

$$P = K\frac{Qnt}{4r^2}\cdot\left(\frac{A}{u^2}\right)^2\cdot\operatorname{cosec}^4\frac{\phi}{2},$$

where A is the atomic weight. The striking agreement of their results with the predictions of the Rutherford theory certainly lend it great support. It surely deserves careful consideration to see whether other conclusions from it may be tested experimentally and whether other atomic phenomena may be explained by it. Assuming the correctness of the Rutherford formula, Geiger and Marsden computed from an absolute determination of Q and the other quantities involved, the positive charge which must be assumed to be concentrated at the centers of the atoms of the metals investigated; and they found that it is, within 20 per cent., numerically equal to half the atomic weight in each case times the charge of an electon; that is,

$$N = \frac{A}{2}(1 \pm .2);$$

a most important conclusion, if true.

Evidently, since hydrogen can not have as a nucleus a charge of $+\frac{1}{2}e$, it must be an exception; the above law can not hold for all the elements. In this connection some experiments of Kleeman[4] on the relative ionization in various gases, are of interest. He found that the ionization per cubic contimeter of various compound gases by a given agent can be predicted from the ionization by the same agent of the separate elements composing the compounds; that is, ionization is roughly an additive, atomic property. From the results obtained with a number of simple and compound gases, he computed approximately the atomic ionization for various elements as given in the following table:[5]

Agent	Atomic Ionization		Atomic Weight	Atomic Ionization / Atomic Weight	
	β Rays	γ Rays		β Rays	γ Rays
H (gas)	.08	.08	1	.082	.080
C	.46	.46	12	.038	.038
N	.47	.45	14	.034	.032
O	.58	.58	16	.036	.036
S	1.60	1.60	32	.050	.050
Cl	1.44	1.44	35.5	.040	.040
Br	2.67	2.81	80	.033	.035
I	4.10	4.50	127	.032	.035

While other factors enter, such as the valence or the position of the elements in the periodic table and chemical linkage with other atoms, atomic ionization seems to depend primarily on the atomic weight, which is probably proportional to the number of electrons in the atom. The fact that hydrogen has approximately twice the atomic ionization which should correspond to its atomic weight, suggests that it may have twice as many electrons in proportion to its atomic weight as the other elements—in agreement with the above conclusion from the Rutherford theory. It is also noteworthy that canal ray deflection experiments performed by Sir J. J. Thomson, Wien, Koenigsberger and others have given no evidence for the existence of doubly charged hydrogen atoms in a discharge tube, whereas doubly charged atoms of other gases are often present. This would tend to confirm the conception of the hydrogen atom as a small positive nucleus with a single electron revolving as a satellite around it.

As for helium, we may suppose, perhaps, that α particles, since they are projected from radioactive substances with such enormous velocities, are stripped of all satellite electrons; that α particles are merely positive nuclei with a charge of $+2e$. If so, the number of satellite electrons in the neutral helium

[3] *Phil. Mag.*, 25: 604, April, 1913.

[4] *Proc. Roy. Soc.*, 79A: 220, 1907; 83A: 530, 1910.

[5] *Proc. Roy. Soc.*, 79A: 220, 1907.

atom must be two, or half its atomic weight—also in agreement with the Rutherford theory.

So far so good. But when we consider the hydrogen and helium spectra, we get into difficulty immediately. Stark, Fischer and Kirschbaum,[6] from a recent careful study of the Stark-Doppler effect in connection with helium canal rays, conclude that the series of single lines which Runge and Paschen ascribe to "parhelium" are emitted by the doubly charged helium atom. Also, according to Stark's hypothesis (which, though not proved, yet seems probable from certain indirect evidence) the hydrogen series lines are emitted by the single charged hydrogen atom. Now, both the "parhelium" and the hydrogen series lines show the normal Zeeman effect and therefore can not be emitted by systems devoid of vibrating electrons. Stark's hypothesis therefore demands a more complex atom; it is incompatible with the Rutherford theory as far as hydrogen and helium are concerned.

Also, recent experiments seem to associate the compound spectrum of hydrogen with the positively charged molecule. It is of course enormously complex. Many of its lines show a normal Zeeman effect, others an abnormal effect, others apparently no effect at all.[7] How such a spectrum can be due to the vibrations of a single electron around two positive nuclei seems inconceivable.

Certainly the Rutherford atom seems much too simple to explain these spectral phenomena, though perhaps these and other objections may be overcome. Is this conception of the atom the only one which leads to the expression for the distribution of scattered α rays which Geiger and Marsden have so thoroughly verified? If possible, the scattering effect of hydrogen should be tested. Perhaps this might be done by the use of a compound of hydrogen or liquid hydrogen. Such experiments on the scattering of α and β rays seem our most promising means of securing more exact knowledge of the actual structure of atoms; but the conceptions thus suggested must explain or be in accord with a wide variety of atomic phenomena before they can expect general acceptance.

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June 27, 1913

[6] *Ann. d. Phys.*, 40: 499, March, 1913.

[7] Dufour, *Annal. chim. phys.* (8), 9: 413, 1906.

NOTES ON ENTOMOLOGY

Economic entomologists will welcome the appearance of a new monthly journal—*The Review of Applied Entomology.* It is published in London (Dulau & Co.) and issued in two series: series *A*, agricultural; series *B*, medical and veterinary. It consists almost wholly of reviews of other works, or reports sent in by various investigators. The journal is supported by the Imperial Bureau of Entomology, and Guy A. K. Marshall is the editor, while a series of distinguished entomologists and naturalists form a committee of management. The parts so far issued average 32 pages for series *A*, and 20 pages for series *B*. In series *B* there are references to new species in certain groups of general medical importance, as mosquitoes and Tabanidæ.

The perfection of preservation of the amber insects has made them a most attractive field of study. Most fossil insects are so discouragingly imperfect, that a knowledge of the actual structural details of some prehistoric insects is a most welcome contribution to the phylogeny of the group. And when this is brought out by so able a specialist in the group as by Dr. G. Ulmer in his "Amber Trichoptera"[1] we can place confidence in the interpretations. Probably the most important point is that the Limnephilidæ, now a dominant family in northern Europe, is lacking in amber, although all other families are represented, and the Sericostomatidæ by many remarkable genera. The presence of a few genera such as *Ganonema, Marilia* and *Triplectides,* now occurring in tropical regions, give one the impression (probably erroneous) of a warmer climate. Besides describing in detail the genera (56) and species (152) known from amber Dr. Ulmer presents many

[1] "Die Trichopteren des Baltischen Bernsteins," Schriften Physik.-Okonom. Gesellsch. Königsberg; Beiträge zur Naturkunde Preussens, Heft 10; 380 pages, 480 figs., 1912.